Report for 2002MN2B: Effects of Riparian Forest Harvest on Instream Habitat and Fish and Invertebrate Communities

- Other Publications:
    - N. Schlesser, D. Atuke, R. Newman and B. Vondracek. 2004. Effects of riparian forest harvest on habitat and fish assemblages in Northern Minnesota. 65th Annual Midwest Fish and Wildlife Conference, 14 December 2004, Indianapolis, IN.

Report Follows

Effects of Riparian Forest Harvest on Instream Habitat, and Fish and Invertebrate Communities

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Executive summary
Stream riparian zones are critical to the health of stream fish and invertebrate communities. Forest harvest within the riparian zone may thus impact stream fish and macroinvertebrate communities and the determination of the level of acceptable harvest within the riparian zone is important to balance forestry needs with stream biotic integrity. This is an ongoing manipulative experiment focused on determining the effects of no, low and high levels of riparian harvest on stream habitat and fish and invertebrate communities. This report provides a summary of the findings of the first year post-harvest data collection, conducted in summer 2004. Total number of fish species sampled was similar for 2003 and 2004. Although the total number of individuals was higher in 2004, this is a reflection of large increases in a few streams rather than a general trend. Index of Biological Integrity (IBI) scores were comparable and similar in 2003 and 2004. Macroinvertebrate community indices indicate within-site and between-site variability but none were significantly different ($p>0.05$). The qualitative habitat evaluation index (QHEI) scores exhibited variability between reaches and between treatments and none were significantly different ($p>0.05$). Dissolved oxygen and pH exhibited similar trends in both pre- and first year post-harvest data. In contrast nitrate, alkalinity and conductivity showed considerable variability in 2004 in comparison to 2003 at all sites. These year-to-year differences between sites and between treatments indicate the need to continue monitoring for longer time to define the effects of riparian forest harvest. Second year post-harvest sampling will occur in summer 2005.

Introduction
Forest products are an important natural resource in the upper Midwest. In Minnesota, timber harvest has been increasing and will continue to increase in the near future (Anonymous 2001). Timber harvest activities have the potential to degrade water quality and aquatic resources and for this reason, best management practices (BMPs) or site-level forest management guidelines have been adopted to protect riparian and aquatic resources in Minnesota (MFRC 1999, Anonymous 2001). Although these BMPs are based on the best available scientific information, and implementation monitoring is being conducted (Anonymous 2001), they have not been evaluated for effectiveness at protecting aquatic resources. Most research on the effects of forest harvest on streams and the effectiveness of forest harvest BMPs has been conducted in more mountainous regions such as

Tasmania (Davies and Nelson 1994), the Sierra Nevada, the Pacific Northwest and Appalachia (e.g., Castelle and Johnson 2000). Results from these areas may not be directly applicable to the midwest (Perry et al. 1992).

Riparian zones provide many protective services to streams (Castelle and Johnson 2000). Determination of the necessary width of riparian buffers (e.g., Castelle and Johnson 2000) or the permissible level of harvest within a buffer is essential to adequately protect stream resources without removing a large portion of the basin from harvest. Most studies on the effectiveness of riparian buffers at protecting streams from upslope harvest have focused on the width of the buffer and have not considered harvest within the buffer zone (e.g., Castelle and Johnson 2000). Current Minnesota BMPs allow varying degrees of harvest within the riparian management zone (RMZ). Harvest within the RMZ may be used to promote regeneration of shade intolerant species. Thus. it is important to know the level of harvest that reduces it's the effectiveness of the RMZ in maintaining stream quality.

The objective of this project was to experimentally determine the effectiveness of various levels of riparian forest harvest on in-stream resources. We examine site-based effects associated with high, low and no riparian harvest (30m Riparian Management Zone, upland clearcuts) on aquatic habitat, macroinvertebrates and fish. Specifically, we evaluate effects on fish and invertebrate habitat (temperature, sediment composition, embeddedness, depth, width, cover, bank stability, canopy coverage, and woody debris, etc.), and benthic macroinvertebrate and fish communities.

Methods

The study sites range across northern Minnesota and are located in Beltrami, Carlton, Cook, Lake, and St. Louis counties. Eight pairs of treatment sites (streams) were located and harvest plots marked in 2003. Within each pair, a riparian control (no riparian harvest with upland clearcut) and one riparian management treatment (low or high residual basal area with upland clearcut) were established to compare the effects of different residual basal area levels (e.g., 4 high basal area and 4 low basal area replicates). We were also able to establish a non-harvested control (both upland and riparian zone not harvested) at seven of the eight plots (beaver activity preclude a non-harvested control plot at one site). Target riparian harvest treatments in winter 2004 were high residual (11.9 m^2 basal area/ha remaining) or low residual (6.3 m^2 basal area/ha). During harvesting, the target residual basal area was not always met and actual values varied by ± 0.9 m^2 basal area/ha.

All sites were sampled for habitat, fish and invertebrates in summer 2004 (post-harvest). This includes the one high residual basal area plot (Reservation River Tributary) that was not harvested in winter 2003-2004. Harvesting on this plot was completed in winter 2004-2005.

Sampling in 2004 was done on the same reaches that were established in the no-harvest control, riparian control and riparian harvest plots in 2003. Within each plot, we sampled 100-meter reaches above the plot (upstream), within the plot (downstream most 100m) and below the plot (100m downstream of plot) – this design provides internal upstream controls and allows for assessment of downstream effects. Ideally, at a given site, we

would generally sample nine 100-m reaches; up-, within and below at the non-harvested control, the riparian control and the harvest treatment. Due to spatial and habitat constraints, up and below reaches were not always feasible for some sites.

Temperature monitoring: Temperature loggers (Optic StowAway®, Onset Computer, Pocasset, MA) were placed in all reaches at each site in May 2003 and 2004. Temperature was recorded at 30 min intervals until removal in October or November.

Water quality: Water quality was recorded in the within reaches at each site in spring and fall: in the field, conductivity, dissolved oxygen, and pH were recorded with a Quanta Water Quality Monitoring System® (Hydrolab Corporation); alkalinity (methyl orange; mg $CaCO_3$) was determined by titration, and orthophosphate was determined by the PhosVer 3 (Ascorbic Acid) method with a Hach model DR/2000 spectrophotometer. Nitrate was determined spectrophotometrically (APHA 1989) on samples preserved in HCL with a Spectronic 1201 Dual Beam spectrophotometer in the laboratory.

Instream habitat: In July, each 100-m reach was sampled for habitat characteristics following the methods of Merten (1999) that are modifications of methods given by Bailey et al. (1993). Variables measured include visual estimates of bank cover, channel stability, cover, woody debris, percent riffles, runs and pools, and aquatic plant coverage. Canopy coverage was determined in each reach with a spherical densiometer. Streambed sediment and substrate type and size (e.g., percent silt, sand, gravel, cobble, etc.) and percent embeddedness were characterized along 14 transects placed at regular intervals in each reach with a maximum total of 56 measurements per reach. Mean depth, velocity and discharge were measured at the fourteen transects within each reach. A qualitative habitat evaluation index (QHEI) was calculated from these data. Blow-down trees were also recorded in each reach.

Benthic macroinvertebrates: Benthic macroinvertebrates were assessed in July following the family-level, composited, multi-habitat rapid bioassessment protocol (Barbour et al. 1999) in each of the upstream (internal control) and within-plot reaches for the control, riparian control and riparian harvest plots. Two composited samples of 20 kicks / net (each sample representing 50 m) were collected with a D-net in each 100-m reach. Samples were sorted and macroinvertebrates identified to family in the laboratory.

Fish assemblages: Fish assemblages were sampled in August. Sampling was conducted in the up- (internal control), within- and downstream reaches at each treatment plot (including the control sites) with pulsed DC electrofishing (Wisconsin AbP-3 backpack shocker) following the protocol of Simonson and Lyons (1995). Fish were identified to species, measured (total length), weighed and returned to the stream. Cold-water Index of Biotic Integrity (IBI) values were calculated according to Mundahl and Simon (1998), and warm-water IBI values according to Karr et al. (1986) and Lyons (1992) to assess the environmental health of the stream fish communities. Species richness, species abundances and IBI scores (normalized to 100) were analyzed to determine the effects of harvest treatment.

Results to date

Instream habitat: There was substantial variation in habitat characteristics between sites. Water temperatures varied among sites and overall, temperatures were below normal in August and above normal in September. However, the trout streams (Reservation River Tributary, West Split Rock River, East Branch Beaver River, and East Baptism River) maintained temperatures ≤ 19 ˚C throughout the summer (range from 12-19˚C), whereas other streams had summer maxima up to 25 ˚C. Conductivity and alkalinity ranged from 32 µS/cm and 20 mg $CaCO_3$/L, respectively at the Cloquet River Tributary to 228 µS/cm and 127 mg $CaCO_3$/L at Shotley Brook. Dissolved oxygen was above 7.5 mg/L at all sites and the pH was > 7.5 at all sites, except the Cloquet River Tributary where pH was 7.2. Orthophosphate ranged from 5 µg-P/L to 170 µg-P/L. However, during both seasons, most sites had less than 50 µg-P/L. Spring nitrate concentrations were comparable to 2003 and ranged from 0.36 mg-N/L to 0.97 mg-N/L. However, nitrate concentrations in fall 2004 were higher and ranged from 0.95 mg-N/L to 1.80 mg-N/L.

Qualitative habitat evaluation index scores ranged from 45-78. There were no significant differences in QHEI between sites and treatments. However, in general the smaller intermittent flowing streams had lower QHEI scores compared to the larger perennial streams.

Macroinvertebrate communities: Macroinvertebrate indices indicated both within-site and between-site variations. In the low RBA sites, mean number of individuals per net varied from a minimum of 298 to a maximum of 1598, species richness had a range of 6-21 families, percent EPT taxa ranged from 0-25%, while percent Chironomidae varied from 10-60%. In the high RBA sites, mean number of individuals per net varied from 356-2164, species richness had a range of 14-20 families, percent EPT taxa ranged from 16-44%, and percent Chironomidae had a range of 34-75%.

Fish assemblages: Seventeen species of fish were found among over 2600 fish collected. Total number of individuals was higher in 2004, but reflected large increases in a few sites (Reservation River Tributary and East Branch Beaver River) rather than a general trend. We observed a reduction in the percentage of brook trout sampled in 2004 in West Split Rock River and East Branch Beaver River.

Indices of biotic integrity were computed using the appropriate warm or coldwater IBIs. The IBI scores ranged from 15-95 (out of 120) in the trout streams and 22-45 (out of 100) in the mud minnow dominated streams.

Ongoing work

Second year post-harvest data will be collected in summer 2005. Habitat and invertebrate samples will be collected in July and fish will be sampled in August.

Summary of findings

Significant variability was observed in the number of individuals and species of fish and macroinvertebrates between 2003 and 2004, but there was no obvious trend that could be discerned in relation to harvest. QHEI and IBI scores between years were not

significantly different although year-to-year variation was observed. Water quality attributes such as temperature, conductivity, alkalinity, phosphorus and nitrates also indicate seasonal and annual variability. Further monitoring will occur in the next two years.

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Related grants submitted or funded as a result of this project

The Legislative Commission on Minnesota Resources funded the initial manipulation, travel, supplies and field assistance and the Minnesota Forest Resources Council provided $10,000 for some supplies and field assistance.

Vondracek, B. and R.M. Newman. Effects of riparian forest harvest on instream habitat and fish and invertebrate communities. Minnesota Department of Natural Resources, 6/15/04-6/30/05. $37,500: funded travel, supplies, field assistance and one additional graduate student.

A proposal for continuation of this project (2005-2007) has been recommended for funding ($97,700) by the Legislative Commission on Minnesota Resources.

Description of student training provided by project:

Directly funded:
Name: Dickson Atuke
Program: Fisheries and Aquatic Biology Track in Conservation Biology
Degree being sought: PhD

Funded by other sources (Fellowships, MN DNR and LCMR grants):
Name: Nicholas Schlesser
Program: Fisheries and Aquatic Biology Track in Conservation Biology
Degree being sought: MS

Name: Nathaniel Hemstad
Program: Water Resources Science
Degree being sought: PhD

Name: Matt Ihnken
Program: Department of Fisheries, Wildlife and Conservation Biology
Degree being sought: BS